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(54) Apparatus for use in drilling

(57) A drilling derrick (15) is provided with two upwardly extending guide rails (17). A support frame (16) is slidably mounted on the guide rails (17). The support frame (16) supports a top drive (10), a pipe wrench (26,31), and pipe positioning apparatus (23). The top drive (10) comprises a hydraulic motor having a hollow shaft (30) with threads at each end. The upper end of the hollow shaft is connected either directly or indirectly to a drilling swivel (11) which is attached by bails (12) to a travelling block (13). The other end of the hollow shaft is connected either directly or indirectly to the drill string. The top drive (10) can be pivoted in a substantially horizontal plane away from the vertical axis of the drill string. The pipe positioning apparatus (23) is mounted beneath the top drive (10) and can be used for picking up pipe and positioning it so that the pipe threads can mate precisely with the threads of the shaft thereabove.

FIG.1

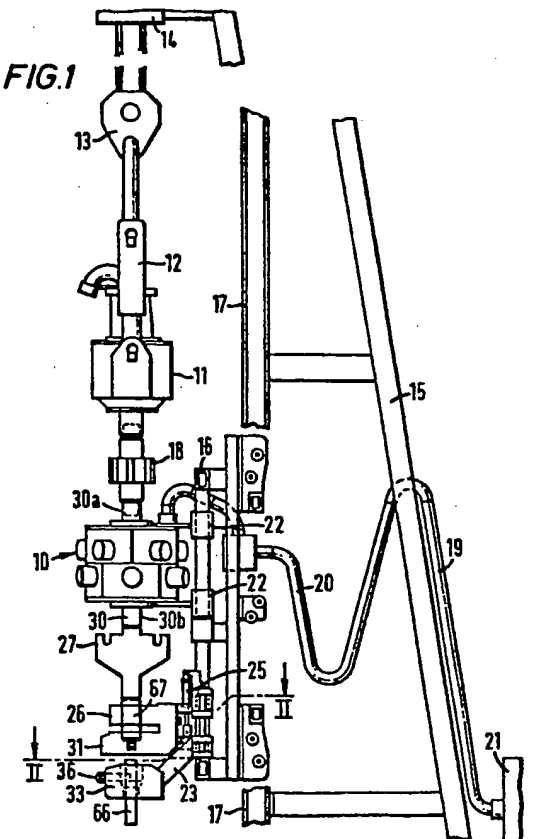

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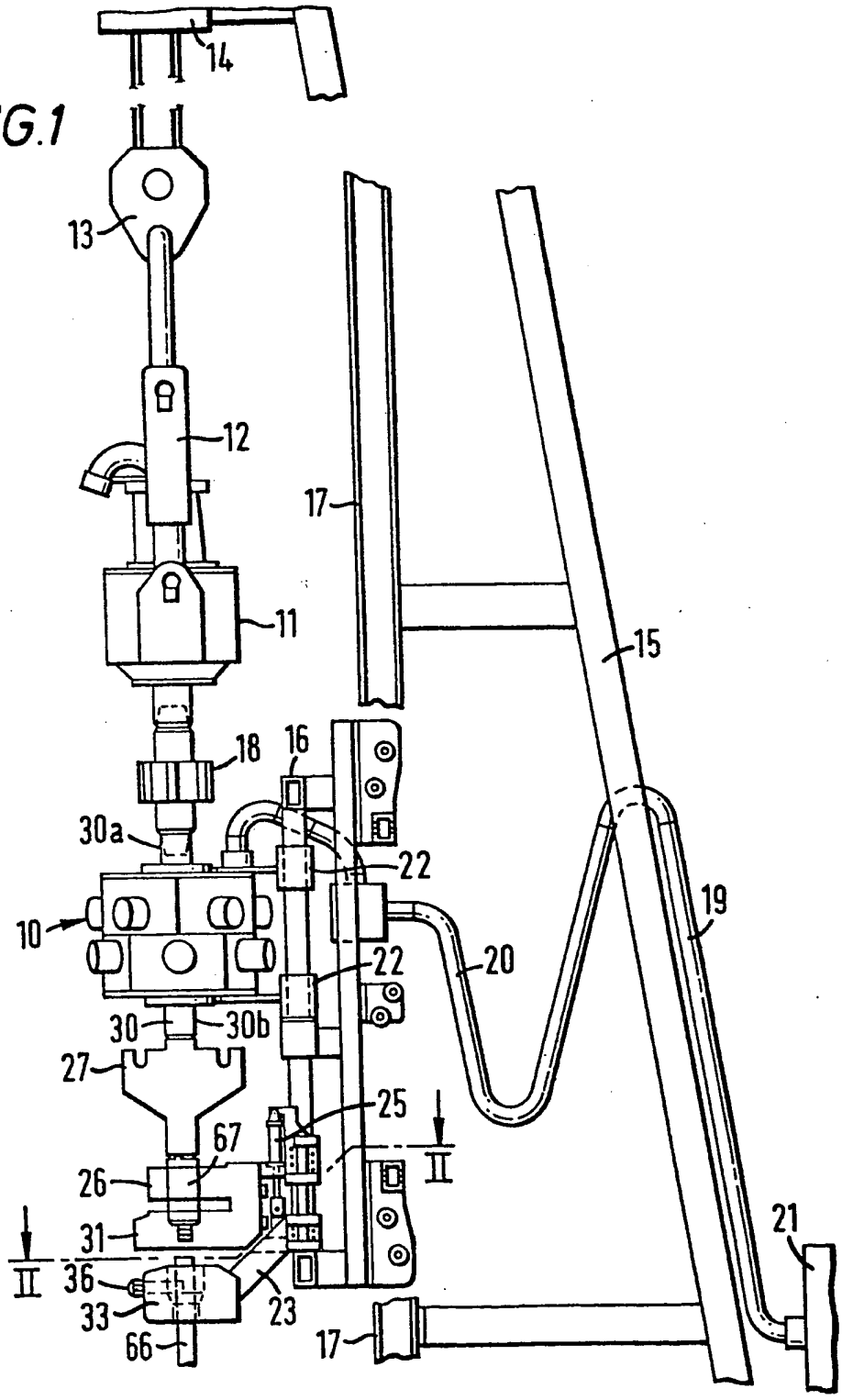
FIG.1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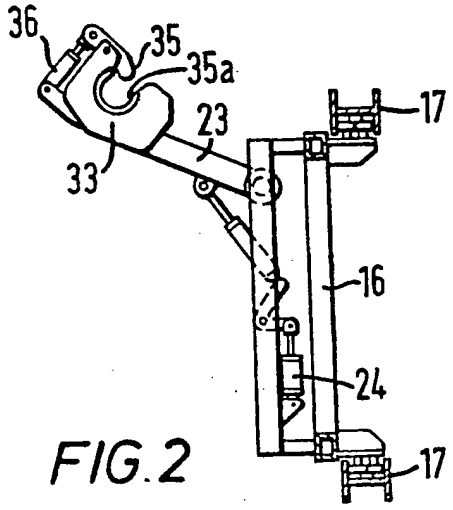

FIG.2

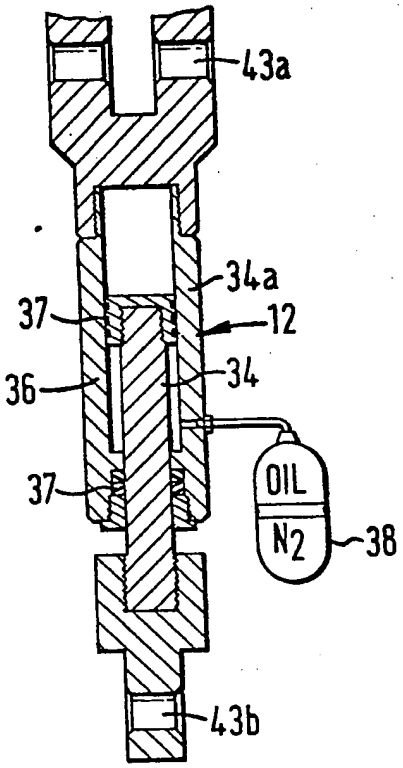

FIG.3

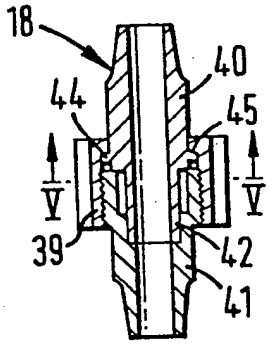

FIG.4

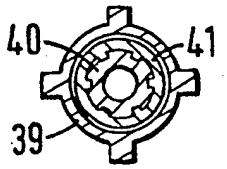

FIG.5

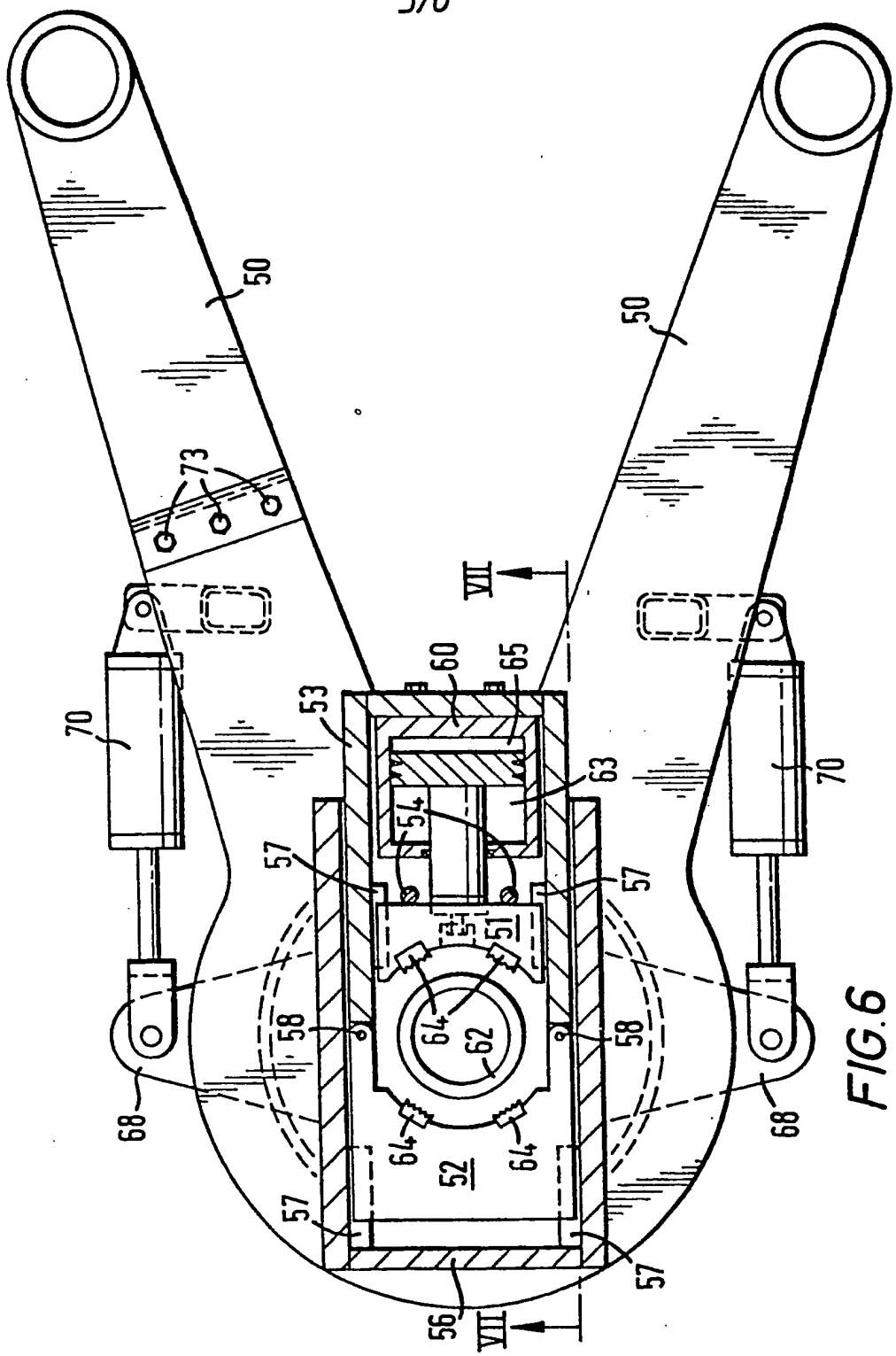
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FIG.6

FIG.7

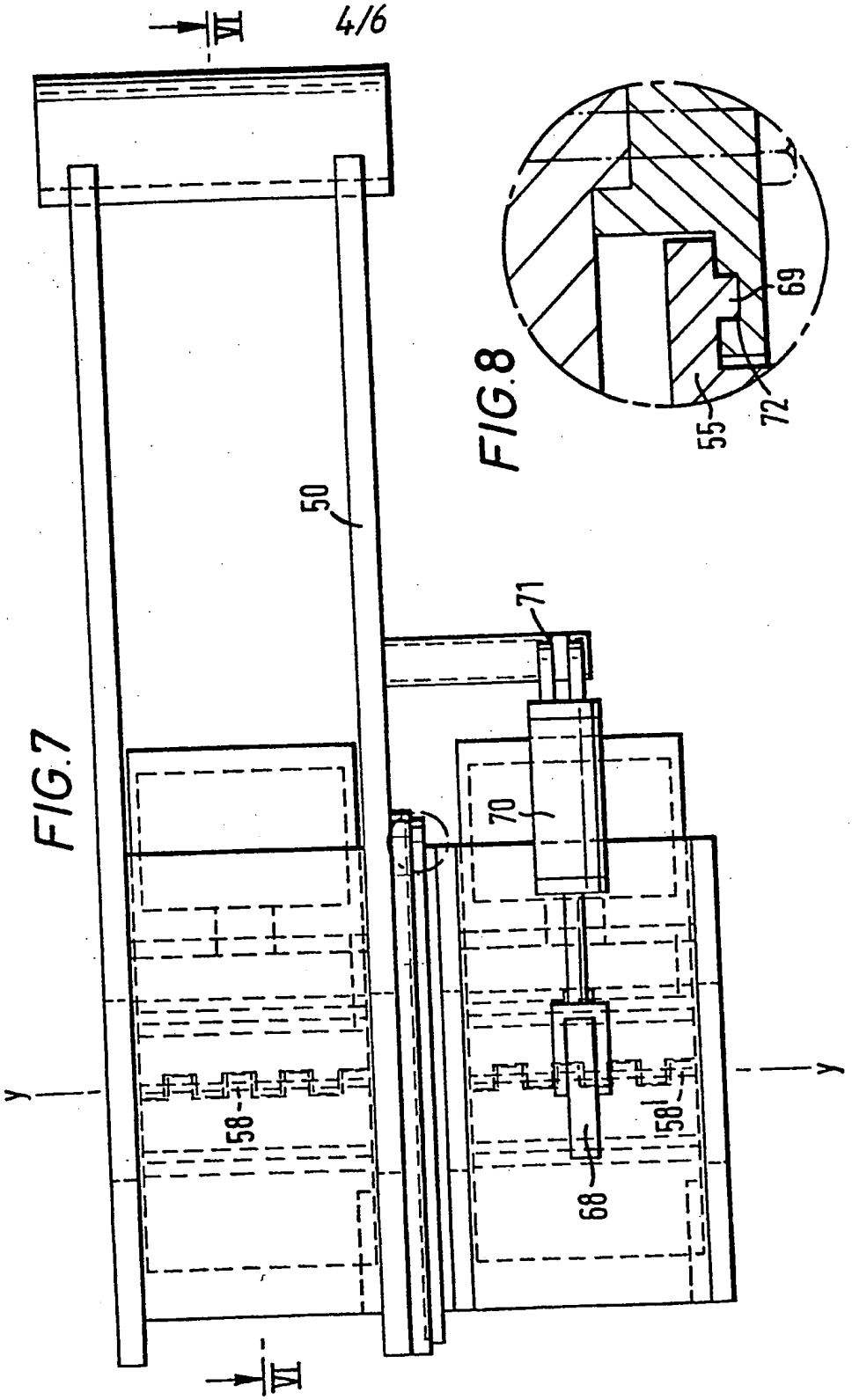

FIG.8

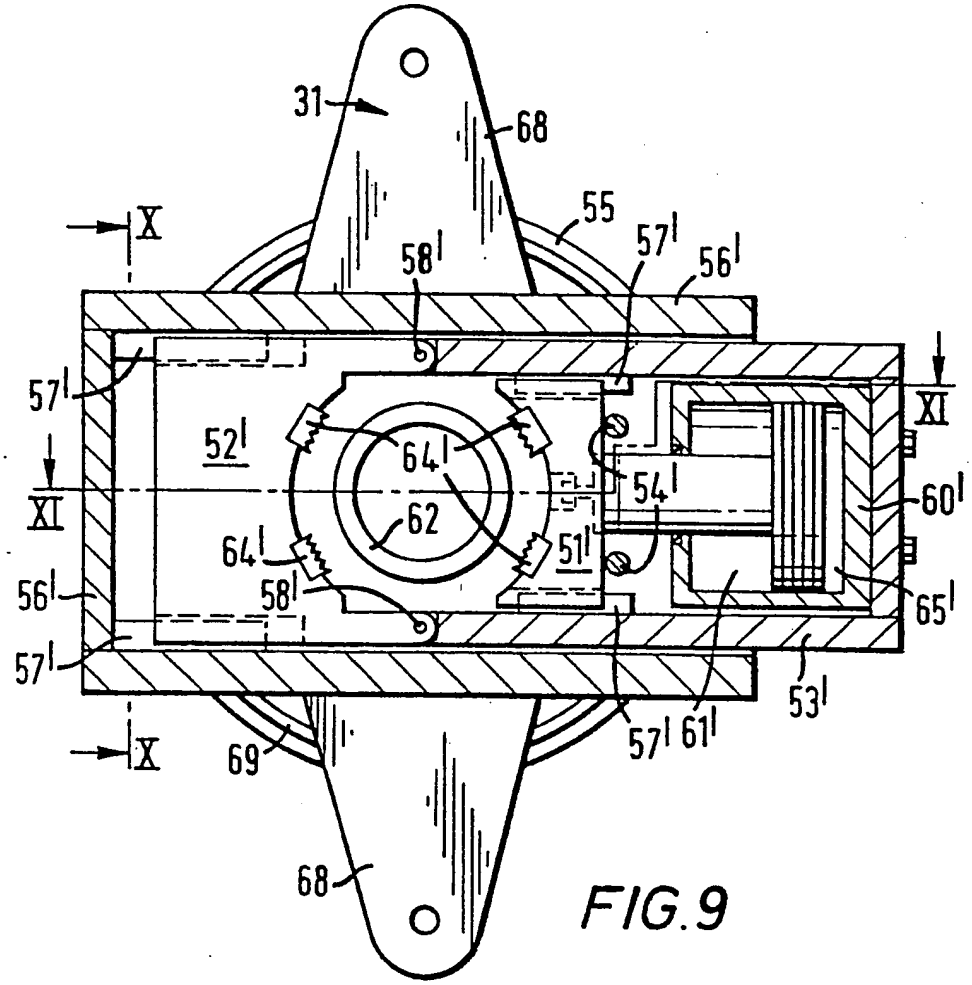
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FIG.9

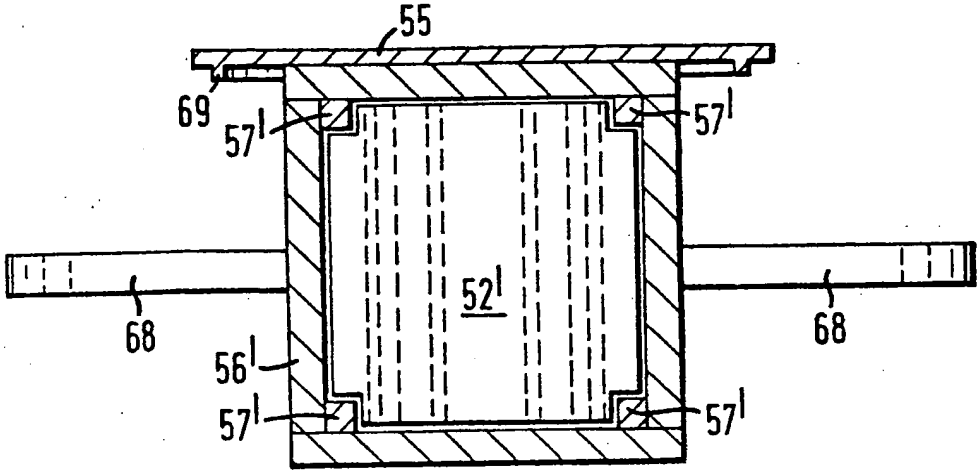

FIG.10

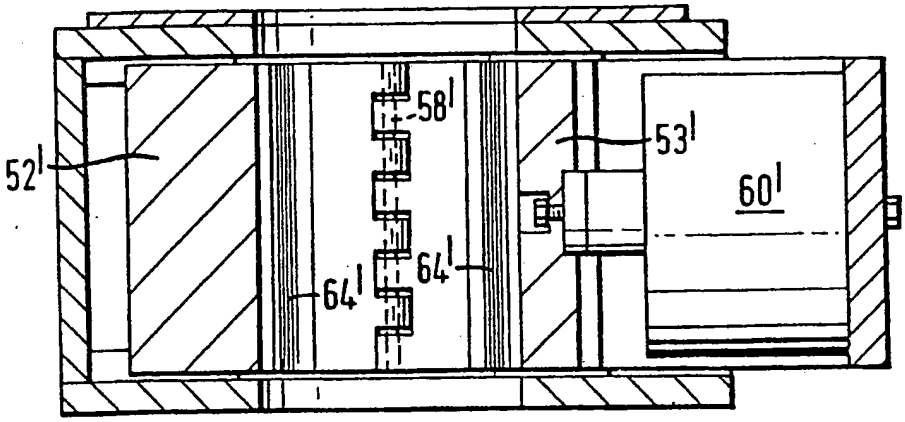

FIG.11

SPECIFICATION

Apparatus for use in drilling

This invention relates to apparatus for use in drilling.

It has previously been the practice in drilling operations to rotate the drill string or other tubular members being worked by means of a rotary table drive or an electric motor top drive. Rotary table drives are inefficient and costly. Electric top drives have had numerous problems; for example, to move and support drill strings weighing up to 500 tons, the direct current traction motors used must be very large, consequently they require a large and effective motor cooling system. Above all, there are considerable potential safety hazards associated with the use of an electric top drive. Because of these potential hazards obtaining compliance with accepted safety codes and insurance certification for the use of electric top drives has been a tedious, expensive, and time-consuming process. There are also numerous structural and functional disadvantages associated with the use of electric top drives. Thus, one prior art electric top drive utilizes an expensive thrust bearing to support the drill string. Another prior art electric top drive has an electric motor which is offset from the shaft supporting the drill string which results in an imbalance in the distribution of the reactive torque applied.

According to one aspect of the present invention there is provided, in or for use in a drilling rig having at least two upwardly extending guide rails, apparatus comprising:-

a) a support frame, which can be mounted on said guide rails and which can be moved therealong, and

b) a top drive mounted on said support frame, characterized in that

c) said top drive comprises a hydraulically actuable motor having a hollow drive shaft.

Preferably, said top drive is mounted on said support frame so that, in use, it can be pivoted in a generally horizontal plane between an operative position and a maintenance position.

Advantageously, said apparatus includes pipe positioning means mounted on said support frame and operable to lift pipe into position beneath said top drive.

Preferably, said pipe positioning means is mounted on said support frame so that, in use, it is displaceable in a generally horizontal plane.

Advantageously, the apparatus includes a pipe wrenching device mounted on said support frame so that, in use, it is displaceable in a generally horizontal plane.

The present invention also provides in or for use in a drilling rig having at least two upwardly extending quide rails, and a support frame which can be mounted on said guide rails and which can be moved therealong, apparatus for positioning a pipe comprising:-

a) a positioning arm,

b) a bowl in said positioning arm for supporting a pipe;

c) a lateral opening in said bowl for allowing a pipe to enter said bowl.

d) retractable latch means disposed across said opening, and

e) means for connecting said apparatus to said support so that said apparatus can be displaced, in use, in a generally horizontal plane.

Preferably said apparatus includes means for, in use, raising and lowering said positioning arm.

For a better understanding of the invention and to show how the same may be carried into effect reference will now be made by way of example to the accompanying drawings in which:-

Figure 1 is a schematic elevation of a drilling rig provided with apparatus according to the present invention;

Figure 2 is a top plan view of the pipe positioning apparatus taken on line II–II of Fig. 1;

Figure 3 is a sectional view of a bail link;

Figure 4 is a sectional view of a splined quick disconnect;

Figure 5 is a section on line V–V of Fig. 4;

Figure 6 is a top view, partially in section, of a breakout/makeup wrenching device assembly;

Figure 7 is a side view of the assembly of Fig. 6;

Figure 8 shows, on an enlarged scale, a detail of the assembly shown in Fig. 7;

Figure 9 is a bottom view, partially in section, of the lower section of the assembly of Fig. 7;

Figure 10 is a section on line X–X of Fig. 9; and

Figure 11 is a section on line XI–XI of Fig. 9.

Referring now to Fig. 1, a top drive 10 is suspended from a commercially available swivel 11 fitted with optional bail links 12. The bail links 12 are, in turn, attached to a travelling block 13 which is attached by cables to a crown block 14 in the derrick 15. The top drive 10 is attached to a support frame 16 which is slidably mounted on quide rails 17 which are mounted on the derrick 15. The attachment of the top drive 10 to the shaft of swivel 11 may be made through a one piece threaded hollow shaft or by using a splined quick disconnect 18. The hydraulic fluid which operates the top drive 10 is conducted through pipes 19 and hoses 20 from a power unit 21 located at a convenient point. The top drive 10 has a hollow shaft 30 with a threaded top end 30*a* for connection to the splined quick disconnect 18.

The top drive 10 is attached to the support

frame 16 in such a manner that it may be rotated in a horizontal plane about pivots 22 on the wheeled support frame 16 for maintenance or removal from service. A drill pipe positioning arm 23 is also pivoted from the support frame 16 in such a manner that it may be rotated in a horizontal plane to a drill pipe pick-up point using cylinders 24 (Fig. 2). The drill pipe positioning arm 23 may be moved to a point which positions the drill pipe 66 directly over the centerline of the well being drilled. Additional cylinder(s) 25 (Fig. 1) then elevate the drill pipe 66 to allow a screwed connection to be made to either: the threaded bottom end 30*b* of hollow shaft 30, the threaded bottom end of an elevator link adaptor 27 (when it is used), or to the threaded end of the saver sub 67 when it is used. Since the motive force of the top drive 10 is centred about the hollow shaft 30, the reactive forces are substantially balanced and a substantially concentric balanced force is imparted to the drill string.

A wrenching device having an upper section 26 and a lower section 31, is also pivotably connected to the support frame 16 in such a manner that it may be rotated aside in a horizontal plane to allow access for maintenance or removal.

Referring again to Fig. 1, the positioning arm 23 is provided with a bowl 33 which has a tapered seat to match the drill pipe tool joint. A lateral opening 35*a* is provided across which extends a latch 35. The latch 35 can be displaced to allow the entry of a drill pipe. The latch 35 is spring loaded to the closed position. Drill pipe may be loaded by pushing into the opening 35*a*. A cylinder 36 is used to move the latch 35 to the open position. Cylinder 25, when actuated, moves the drill pipe 66 into contact with the mating thread on the saver sub 67. The latch 35 may also be actuated manually.

Referring now to Fig. 3, each bail link 12 has a piston 34 which is biased upward in a cylinder barrel 34*a* as a reslt of fluid under pressure entering the interior of the barrel 34*a* from an accumulator 38. The internal force acts like a compression spring. When the piston 34 is actuated downward by a load the potential energy is stored within the hydraulic accumulator 38. When the load is next reduced, such as when a section of the drill string is being unscrewed, the distance between the attaching holes 43*a* and 43*b* will decrease, the drill string proper will remain stationary in the hole and the swivel 11 will move upward as the threaded members of the drill string are separated. When the sections are unscrewed the upper section is raised clear of the drill string proper by the action of the piston 34 within the barrel 34*a*. When the load is entirely removed, the distance between the attaching holes 43*a* and 43*b* will be at minimum. Packing seals 37 are provided circumjacent the piston 34.

Referring to Figs. 4 and 5, the splined quick disconnect 18 comprises (a) a tubular member 40 provided with a male spline and an extension bearing a sealing element 42, and (b) a section 41 provided with a female spline which co-operates with the male spline. A threaded collar 39 mates with the threads on the section 41. An inside shoulder 45 on collar 39 abuts a projection 44 on member 40 and thereby locks the assembly as a splined and sealed unit. Torque is transmitted through the splines.

Referring to Fig. 6, the upper section 26 of the wrenching device has a box section 56 securely attached to support members 50. A die block 52 is attached to inner die carrier 53 by pins 58. Die blocks 51 and 52 are able to move inward or outward on guides 57. Cylinder 60, when pressurized in chamber 65, moves die block 51 into contact with tubular workpiece 62. As die block 51 engages workpiece 62 a reaction force moves inner die carrier 53 in a direction away from workpiece 62 until die block 52 which is attached to inner die carrier 53 is forced to engage workpiece 62. In operation, pressure in chamber 65 creates a gripping force which firmly engages serrated dies 64 against the workpiece 62. In the reverse action, cylinder 60 is pressurized in chamber 63 causing die block 51 to move away from workpiece 62. After partial travel, die block 51 will contact stops 54 which will cause the body of cylinder 60 and the inner die carrier 53 to move inward toward the workpiece 62. This action forces the die block 52 away from workpiece 62.

Referring now to Fig. 9, which is a bottom view of the lower section 31 of the wrenching device, a box section 56' is securely attached to a circular guide plate 55. Die block 52' is attached to an inner die carrier 53' with pins 58'. Die blocks 51' and 52' are able to move inwardly and outwardly, being aligned by guides 57'. Cylinder 60', when pressurized in chamber 65', moves die block 51' to contact tubular workpiece 62. As die block 51' engages workpiece 62, a reaction force moves inner die carrier 53' in a direction away from the workpiece 62 until die block 52' engages workpiece 62. In operation, pressure in chamber 65' creates a gripping force which firmly engages serrated dies 64' against workpiece 62.

In the reverse action, the cylinder 60' is presurized in chamber 61' causing die block 51' to move away from workpiece 62. After partial travel, die block 51' will contact stops 54' which causes the body of cylinder 60' to move toward the workpiece 62. Since inner die carrier 53' is attached to cylinder 60', inner die carrier 53' will move toward workpiece 62 and force die block 52' away from the workpiece 62, the force being transferred through pins 58' which attach die block 52' to

inner die carrier 53'. Torque arms 68 are securely attached to box section 56'.

Referring to Figs. 8 and 10, the circular guide plate 55 features a guide lip 69 which will be used in attaching the assembly of Fig. 9 to the upper section of the wrenching device shown in Fig. 6.

Referring now to Fig. 11, a typical section through either the top wrenching section or the lower wrenching section is shown illustrating the method of attaching an inner die carrier (53, 53') to a die block (52, 52') using a pin (58, 58').

Referring now to Fig. 7, cylinders 70 are affixed to respective torque arms 68 of the wrenching device through a clevis at the rod end. The barrel end is connected to the upper section through a hinged joint 71 and the reaction is restrained by the upper section. When the cylinders 70 are energized, the lower section will rotate the centerline of the lower die blocks about axis y. The guide lip 69 rotates in annular groove 72 (Fig. 8). When the bolts 73 are removed the wrenching device is free to pivot in a horizontal plane on support frame 16.

With this embodiment well drilling fluids enter the drill string through a conventional flexible hose connected to the swivel 11 shown in Fig. 1. The swivel 11 has a hollow shaft through which fluids pass into the hollow shaft 30 of the top drive 10 and on through the hollow sections of the remaining subs or devices into the interior of the drill string.

The following chart compares certain features (but not all) of the embodiment described with reference to the drawings with the embodiments disclosed in U.S. Patent 4,449,596 and with the Bowen ES-7 Electric Drilling Swivel:

In the following comparison Prior Art is identified by the letters PA and Preferred Embodiment by the letters PE.

Bowen ES-7 Electric Drilling Swivel

PA: Electrical power is conducted from the generating room to the unit through rubber covered electrical cabies. Danger of damaging and sparking is ever present. An accident at a time when well head gasses are present could be disasterous.

PE: Operated by hydraulic fluid. There is no danger of sparking. The hydraulic power unit is located in a safe area.

PA: Complete drilling system weighs approximately 18,000 kg.

PE: Complete system weighs 9,000 kg or less.

PA: In the event of mechanical failure requires complete "rig down"; the replacement of the electric top drive is complex and time consuming.

PE: Unit is designed to accommodate rapid replacement of the hydraulic top drive. Because of this feature several hours of down time are saved.

PA: All installations are equipped with a conventional (rotary table) drive system on "standby" because of high down time if replacement of electric top drive required.

PE: Reliability of this system and ease of replacement would allow users to eliminate the rotary table drive systems, spare hydraulic motors and components are the only "back-up" equipment. This saves hundreds of thousand dollars rig cost.

PA: Hazardous area certificates are required for the numerous safety devices used to monitor systems designed to render this unit safe for use in a hazardous location. This is time consuming and expensive.

PE: Electrical devices are located below the drill floor in a pressured safe room which would, in any event normally already exist. The multitude of monitoring devices used on the electric drive are not required.

PA: During drilling, excessive bit weight or hole friction and stops the drill bit and stalls the electric motor. Common practice is to reduce bit weight. Since full electrical potential remains applied, the drill suddenly accelerates from zero to up to 250 R.P.M. in a matter of seconds. This causes over-tightening of tool joints threads and ruins the drill pipe. Also the drill string may whip and damage the wall of the hole. Mechanical reaction is transmitted to the derrick through the support mechanisms and this vibration damages the structure and is very noisy.

PE: Hydraulic power, because of its inherent nature, is much smoother. The mechanism of the moving fluid are such that acceleration after stall will be smoother and more uniform. Less damage to drill hole and equipment are realized.

PA: Air purging the inside of the electric drilling motor is required at initial start-up and at every time a safety device actuates. This may require 10 to 30 minutes.

PE: No purging is required because there is no air cooling system.

PA: On units so equipped there is a danger of water leaking into the electric motor following any damage or corrosive failure of the water to air heat exchanger used to cool the motor air. These systems are required wherever you find stringent safety measures such as North Sea Platforms. This can cause the motor to fail.

PE: No such system is required.

PA: Making drill pipe connection: The drill pipe is picked up by the elevator bowl and the lower end stabbed in the previous pipe. Human skill is then required to ease the drive shaft down into the thread to screw it up. Thread damage can occur.

PE: The pipe handling device on this unit has a hydraulic lift to engage the thread. Proper adjustment will ensure minimal pressure on the threads. This is much quicker than

when the driller has to execute skill and judgement making up each joint of pipe.

PA: When picking up a length of drill pipe whose end is protruding about 1m above the drill floor, the pipe handler must be tilted outward. Since the bowl of the pickup tool is swivelled, the angle is incorrect for the pipe. Also the latches on the pickup tool must be manually closed which takes time.

PE: Substantially perfect alignment and orientation of the pipe handling mechanism is achieved via mechanical stops and cylinders to create the necessary movement. The latch is spring loaded to automatically lock when the pipe is loaded. A cylinder will actuate the latch to the open position. This is by remote control which is much safer. This system is also much faster than the manual method.

PA: Cost much more.

PE: This system costs much less. This does not take into account the equipment which an operator does not have to buy, such as extra swivel and/or rotary table drive which would make the savings several hundred thousand dollars.

PA: Installing this unit on land rigs or retrofitting to offshore rigs is very complicated because of size and different system.

PE: Retrofit to any existing drilling rig can be accomplished much easier because of size and weight as well as simplicity of design.

PA: The closed circuit air cooling system collects carbon dust which eminates from the bushes. This can lead to internal shortening.

PE: No brushes are used.

PA: Repeated stalling of the main electric motor especially for more than a few moments, under high current will damage the armature and subsequent rotation will lead to failure.

PE: No such stalling problem.

Also, the embodiment described compares favourably to that disclosed in the prior art U.S. Patent 4,449,596 in the following respects:

PA: Requires two circulating swivels because one is integral with sub and one much be used when unit is rigged down.

PE: Only one swivel is required. Current list price for 500 ton swivel (Continental Emsco): $43,290.00.

PA: Requires explosion proof cooling air system. Present design uses blower mounted on support dolly or drill floor and air is conducted through 20cm diameter flexible rubber duct. This lightweight duct is often windblown and damaged from hanging on the rig structure. Hot air is exhausted to atmosphere creating a hazardous condition. Documentation for the alternating current fan motor and approval for the D.C. drive motor is time consuming and expensive.

PE: Hydraulic oil is cooled by rig supplied water being circulated through an oil cooler. This equipment is located in an existing safe location.

PA: The overall height, width and depth is much greater; requires approximately 13.8m of vertical derrick height.

PE: This unit requires less than 10.8m.

PA: The unit does not have a "rise and fall" mechanism to minimize load on drill stem threads when unscrewing.

PE: Counterbalance mechanism is provided.

PA: Unit must be swung back in order to install well casing.

PE: All normal drilling and casing installion is done with standard unit.

CLAIMS

1. A drilling rig having at least two upwardly extending guide rails, a support frame mounted on said guide rails for movement there along, and apparatus for positioning a pipe comprising:-

a) a positioning arm,

b) a bowl in said positioning arm for supporting a pipe;

c) a lateral opening in said bowl for allowing a pipe to enter said bowl,

d) retractable latch means disposed across said opening, and

e) means connecting said apparatus to said support frame so that said apparatus can be displaced, in use, in a generally horizontal plane.

2. An apparatus as claimed in Claim 1, including means for, in use, raising and lowering said positioning arm relative to said support frame.

3. A drilling rig as claimed in Claim 1, wherein said apparatus for positioning a pipe is substantially as hereinbefore described with reference to and as shown in Figs. 1 and 2 of the accompanying drawings.

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